I/O magazine

ICT RESEARCH PLATFORM NEDERLAND

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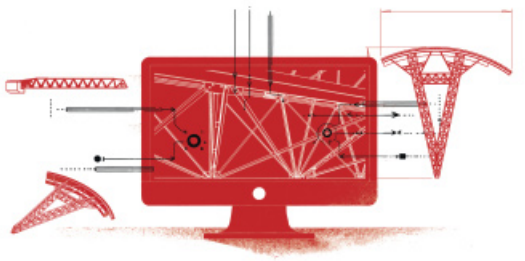


PAUL KLINT

Endangered integrity

The integrity of science is endangered in many ways. How to reverse this trend?

Fabricating data, plagiarising text, stealing ideas. It was not that long ago that we considered a single cheating scientist a threat to scientific integrity. We exposed such behaviour and punished the offenders by retracting their papers and taking away their academic titles and credentials. As a community, we were sending clear signals to other researchers and society: don't worry, science is a self-cleaning system, and our results can be trusted. Those were the days of the romantic past. Today, many larger internal and external threats endanger the integrity of science.

The list of internal threats is impressive. Authors can submit articles completely generated by AI. 'Authors' can buy articles with their name on them; texts are usually scraped from existing papers or are AI-generated. Positions as an author of articles in obscure journals can be purchased. Articles are reviewed by reviewers who unwisely use AI to write the review. Finally, the citations of an article can be boosted by participating in citation farms. Fraudulent publishers and journals enable this ecosystem. Classical human errors, such as copying a text fragment without proper citation or the naive use of statistical methods, pale in comparison to these integrity violations.

External threats are more diffuse but not less dangerous. They range from conspiracy thinkers who reduce science to 'just an opinion' to governments that want to eradicate or at least defame scientific results that are contrary to their political views. Examples include climate change and vaccinations.

My personal dark view on this is that the Enlightenment brought us from the Middle Ages to modern times, but that we are now rapidly going back in time.

Is there anything we can do to reverse this trend? Technical approaches to detect violations will no doubt play an important role. But awareness, both inside and outside of science, is the key. We need to explain what science is about. And maybe, we should follow the example of bankers: they all have to swear the Banker's Oath. How about a Researcher's Oath that declares that this researcher acts with integrity? Is that a foolproof solution? No. Is it naive? Maybe. Will it increase awareness? Yes!

NWO

JPN 25 YEARS ICT-RESEARCH PLATFORM NETHERLANDS

EMBEDDING ETHICS IN THE DIGITAL AGE

The IPN working group Ethics in Computer Science explores ethical issues in conducting computing research, whereas TU Delft's Digital Ethics Centre translates ethical principles into practical design guidelines.

By Bennie Mols

Image iStock

Jeroen van der Ham-de Vos

'We want to ensure that researchers can do better research and not run into problems at a later stage'

Completely unexpectedly, cybersecurity researcher Jeroen van der Ham-de Vos ran into an ethical dilemma in 2012. That year, several internet service providers in the Netherlands blocked the illegal website The Pirate Bay following a court ruling. The Pirate Bay allowed users to share films, music, software and e-books.

Many people felt that the blockade made no sense because it was easy to circumvent', he says. 'I then started taking measurements of illegal files being shared, and indeed I was able to show that the blockade had no long-term effect. But while I was doing that, I also suddenly realised that I now had the IP addresses of people who were sharing illegal files. I didn't know whether that was actually allowed. A lawyer said it was not, but we computer scientists thought it was acceptable because of the greater societal importance. This is how I eventually ended up collaborating with an ethicist to find out what is and is not allowed in our research.'

Later in his career, Van der Ham-de Vos worked for the National Cybersecurity Centre. There, he ran into another ethical dilemma in computer science research: if security researchers find a flaw in a device, how and when should the flaw be made public? Companies often want to keep a leak secret, but disclosure may be in the public interest. Consider, for example, the leak Nijmegen researchers found in the Dutch public transport OV-chip card in 2008. 'This is a problem about vulnerability disclosure', says Van der Ham-de Vos. 'The National Cybersecurity Centre was involved early, making the Netherlands one of the first countries to establish policies for reporting security vulnerabilities.'

Nowadays, Van der Ham-de Vos works as an associate professor in cybersecurity vulnerability management at the University of Twente. A few years ago, motivated by the ethical dilemmas he had encountered himself, he initiated the IPN working group Ethics in Computer Science. 'Its main goal is to do responsible computer science research in the Netherlands', he explains. 'We can achieve this by creating a network, exchanging experiences and drawing up a code of ethics. The working group now consists of a relatively stable group of around twenty-five members, and we are in contact with all the computer science departments at Dutch universities. We have already had some meetings where we have exchanged experiences and we are going to make that more structural in the future.'

Prompted by a report

Apart from the personal ethical dilemmas he had encountered, Van der Ham-de Vos was prompted by the KNAW report 'Ethische en juridische aspecten van informaticaonderzoek' to start the IPN working group Ethics in Computer Science. That report, published in 2016, advised establishing ethical commissions in computer science. 'The KNAW clearly indicated that something needed to be done', he says. 'I already had experience setting up ethics committees and then tried to set up that network so as not to have everyone reinvent the wheel. And I took inspiration from a similar initiative in the social sciences, the National Ethics Council for Social and Behavioral Sciences (Nethics), established in the early 2010s.'

'The IPN working group focuses on researchers engaged in the ethical review of research', he explains. 'Not to frustrate research by just imposing restrictions, but by using the right restrictions to ensure that researchers can do better research and not run into problems at a later stage. Computer science has expanded so much in the last decades that many new ethical issues have arisen. Think about using human subjects for experiments in human-computer interaction or the use of personal data of people and the privacy issues this raises. And increasingly, AI systems are making decisions about humans, which, in turn, leads to completely new ethical questions.'

Developing a code of ethics for computer science research is high on the wish list of the IPN working group Ethics in Computer Science. 'International organisations like the ACM and the IEEE may both have a code of ethics', says Van der Ham-de Vos, 'but they are mainly focused on professional conduct and scientific integrity. There are too few concrete tools in there for dealing with ethical dilemmas in computing research. We want to fill that gap with our working group. I hope this initiative will turn the Netherlands into a frontrunner in doing responsible research in computer science.'

Digital Ethics Centre

While the IPN working group Ethics in Computer Science addresses ethical dilemmas in conducting research, TU Delft's Digital Ethics Centre focuses on translating ethical principles into practical requirements for engineers. 'We

conduct ethical research with a typical Delft signature, called ethics by design', says Jeroen van den Hoven, scientific director of the Digital Ethics Centre. 'The premise is that if you do not address values like democracy, accountability or privacy already at the design level, then you are too late.'

Jeroen van den Hoven

'I believe that working along European values can lead to very interesting innovations'

Van den Hoven gives an example: 'Take the idea that algorithms should be fair. But what does fairness mean? There are twenty to thirty definitions of fairness. Which one should the government use when it comes to social security? Which one should customs choose for automatic border control? Which one is appropriate in military applications that have a form of autonomy? What ratio of false positives to false negatives are you willing to accept? And how will you test whether the system meets your chosen definition of fairness?'

Van den Hoven and his colleagues have developed a methodology that is aligned with the practice of computer science engineers. 'After setting specific requirements for a particular application', he explains, 'a prototype is built and tested to see how well those requirements work in practice. If needed, it is then refined.'

The Digital Ethics Centre originated from the ethics research that Van den Hoven and his colleagues have been doing for decades at the TU Delft Department of Technology, Policy and Management. Van den Hoven: 'In 2017, I initiated the Delft Design for Values Institute, which covers the whole field of technology, from energy transition to water management. However, several years ago, after receiving more and more requests from society specifically about digital technologies, I decided that we needed an institute only for digital ethics.'

The Digital Ethics Centre functions as a kind of project organisation in between all the departments. Van den Hoven: 'It is a loose organisation to which over forty people are now attached. We formulate projects, find PhD students and postdocs for them and then we pass the baton to the department where the project fits best.' In terms of research, the centre focuses on potential applications in healthcare, government and defence. The World Health Organization (WHO) recently recognised the Digital Ethics Centre as an ethics centre of its organisation that specialises in the application of AI in healthcare. In the field of defence, the centre has a lot of expertise in the area of meaningful human control of autonomous weapons, an issue on which Van den Hoven advised the European Commission in 2017.

Building in core values

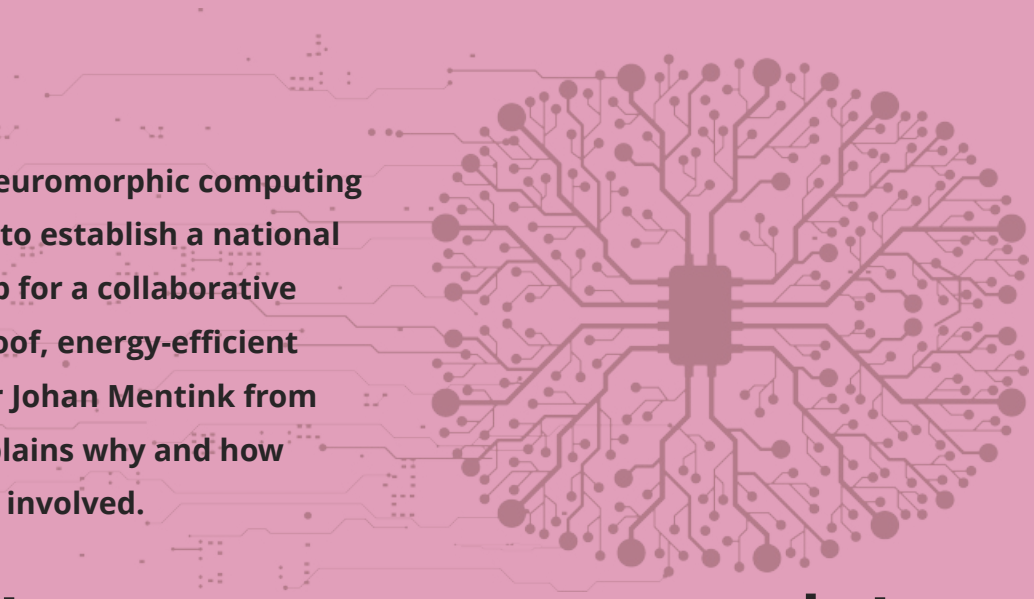
An often-heard complaint is that Europe wants to be the best student in class, thereby putting its own innovativeness at a disadvantage against the US and China. What is Van den Hoven's view on that? 'Of course, we should not be naive', he says, 'but I believe that working along European values can lead to very interesting innovations. People all over the world are moral beings. They may often have different ideas about many things, but on the core moral issues, they frequently miraculously agree. For example, they want to make their own choices in life. They don't want misery for themselves and their children. They want a trustworthy government that cares about citizens, not primarily about the bank accounts and power of politicians. Building such core values into the design of applications will, of course, come with a higher cost in the short run, but society will benefit in the long run. Many citizens and consumers will eventually see that.'

MORE INFORMATION

ict-research.nl/ethics

www.tudelft.nl/digital-ethics-centre

www.knaw.nl/publicaties/ethische-en-juridische-aspecten-van-informaticaonderzoek



Scientists working on neuromorphic computing in the Netherlands aim to establish a national coalition and a roadmap for a collaborative effort toward future-proof, energy-efficient computing. Coordinator Johan Mentink from Radboud University explains why and how computer scientists are involved.

Nurturing neuromorphic computing

By Sonja Knols Image iStock

The biggest promise of neuromorphic computing is that it is way more energy-efficient than current computing paradigms. The human brain uses about 20 Watts, whereas the power consumption of supercomputers is about a million times higher. The key to this difference is the fact that in a brain, data storage and data processing are done at the same place, reducing the amount of data transfer and allowing for massively parallel calculations.

ON THE MARKET

'Developments in neuromorphic computing are going extremely fast. In fact, neuromorphic hardware is already available

'We aim to develop a joint roadmap'

on the market', says Johan Mentink, assistant professor in Theoretical and Computational Physics at Radboud University. 'In the Netherlands, we have a lot of expertise on this topic, but that is not yet sufficiently visible. We recently published a white paper to strengthen the field by showing what neuromorphic computing is, which actors are involved in it, and how neuromorphic computing could impact Dutch society in a positive way. Supported by the Top Sector ICT and SURF we aim to create a "Neuromorphic Computing Alliance" in the Netherlands and develop a joint roadmap.'

'There is a lot of potential for computer scientists to make meaningful contributions', Mentink notes. One of the pressing fundamental questions is where the parallelisation that comes with neuromorphic architectures could be of most use. 'To further develop this field, we need inspiring applications that the current digital infrastructure either cannot cope with, or is too inefficient to accommodate.'

INTRIGUING QUESTIONS

Topics like circuit design, how circuits can be integrated in efficient computer architectures, and what types of algorithms should run in order to make optimal use of the specific properties of a neuromorphic processor, are actively being explored, he explains. 'Other subjects like programming models and automated code generation will also be very important. With several types of neuromorphic hardware and various potential applications, a lot of exploration and benchmarking is needed, which is much easier if it can be automated.'

Another pressing topic that will become even more important is legacy, Mentink emphasises. 'How could we combine new NPUs with existing hardware and software? How can we optimise workflows in such heterogeneous systems? All in all, there are a lot of fundamental and application-oriented computer science questions that need to be tackled.' Mentink therefore welcomes computer scientists to reach out and join the initiative. 'This is an exciting field to explore, especially for people who are currently working on FPGAs or other types of non-traditional architectures. Future computing systems will look different from those of today. It's my firm belief that innovative computing architectures will be the way forward. What could be more exciting than to be at the forefront of such a revolution?'

From 26 to 30 January 2026, the Lorentz Center in Leiden will host a dedicated workshop called 'Sustainable Computing with Neuromorphic and Quantum-Inspired Technologies'. Reach out to Johan Mentink if you are interested in joining: johan.mentink@ru.nl

IPN COLLOQUIA

In 2025, IPN celebrates its 25th anniversary with a special online series of colloquia in which world-renowned computer scientists give their view on the progress in, and future of computer science. These colloquia feature thought-provoking presentations that are of interest to a broad computer science audience. Although these colloquia are initially aimed at the Dutch computer science community, they are open to people around the world. More information and future dates can be found on the IPN website: **ict-research.nl/ipn-colloquia/**.

MAKING SOFTWARE A TOP PRIORITY IN EUROPE

Software is essential to virtually all technological domains – from AI and digital twins to mobility, healthcare and defence. Yet, fundamental software research remains structurally underfunded in Europe. To address this, IPN's Special Interest Group for Software Engineering (VERSEN) has established a European working group in collaboration with similar associations across the EU. The goal: to firmly place software research on the European strategic agenda.
The working group has identified urgent challenges, including dependence on non-European platforms, vulnerabilities in the open-source software supply chain, and a growing shortage of skilled software engineers. In close collaboration with industry, the group is developing a Strategic Research and Innovation Agenda to guide future policy and investments in software research.

FIRST IPN SENIOR LEADERSHIP COURSE COMPLETED

Last spring, IPN organised its first leadership course aimed at senior researchers: potential or new department heads, potential or new IPN board members, and professors who either possess or aspire to gain national influence. In a series of four intense, in-depth meetings, ten computer scientists from all over the Netherlands explored themes such as strategic leadership, diversity, financial policy and administrative expertise. These topics were illustrated and explained by inspiring speakers such as Ed Brinksma, Isabel Arends, Maarten van Steen, Machteld Roos and Mirije van Dijk.
In spring 2026, IPN will organise a second leadership course aimed at juniors who have the capacity to develop into academic leaders in the future: ambitious assistant professors with at least several years of experience, novice associate professors, and tenure trackers.

MAARTEN VAN STEEN RECEIVES IPN DISTINGUISHED SERVICE AWARD

Maarten van Steen, full Professor of Computer Science at the University of Twente, received the first-ever IPN Distinguished Service Award. This award recognises a person who has provided outstanding service to the IPN community.
Maarten chaired IPN from 2015-2020. During this period, he showed exceptional, visionary leadership and acted as a pivotal force behind the transformation of IPN from its traditional structure into the highly successful organisation it is today.
Beyond his transformative work at IPN, Maarten has consistently contributed to shaping national initiatives, including the COMMIT program and the Netherlands AI Coalition. In his current role as Scientific Director of the Digital Society Institute at the University of Twente, he continues to champion the pivotal role of computer science in addressing interdisciplinary challenges modern society is facing.

ICT WITH INDUSTRY: FORGING BONDS THAT LAST

ICT with Industry 2025 was an inspiring and intense experience, according to organiser Kurt Driessens from Maastricht University and case supplier Jerry Jinfeng Guo from Alliander: 'We had to knock on doors to convince the teams to take a break.' During the week-long workshop, teams of four to eight academic researchers worked on four cases provided by Alliander, Contractuo and ING.

Based on interviews by Leendert van der Ent Image iStock

For the 2025 edition of the annual ICT with Industry workshop, organised by NWO in collaboration with the research schools ASCI, IPA and SIKS, associate professor of Artificial Intelligence Kurt Driessens teamed up with Nicole van der Meulen from SURF to find cases for the researchers to work on. ING brought in two cases in this year's edition and Alliander and Contractuo one each. 'What struck me was the heavy emphasis on AI in all four cases', Driessens says. 'The two ING cases concentrated on legacy software. Maybe this does not seem AI-related at first glance, but the angle was about Large Language Model (LLM) aided automated software and documentation development to replace legacy software. The problem with legacy software is that it is written in long-forgotten computer languages. The documentation is sometimes lacking. The team involved in the case investigated how LLMs could help understand the language and system to automatically make documentation about the code. The second case concentrated on translating ancient code into current programming language software.'

The Contractuo case was about automating the tedious parts of tender submittance. Driessens: 'Researchers and people in the corporate world alike will be familiar with building dossiers to compete for grants and contracts. Contractuo aims to use AI and LLM to take over the boring parts. One of the challenges with this is that all legal requirements should be met, as these are updated regularly. Would it be feasible to deploy AI for this and to still comply with all rules and regulations?'

STABLE GRID OPERATION

The fourth case, aiming at optimised grid use on behalf of Alliander, seemed in advance to be more mathematical than AI-driven. But in the end, the most promising solution turned out to be an AI option as well. The workshop participants were asked to come up with strategies to improve current power flow calculations to ensure stable and reliable grid operation. The electrical grid in many regions of the Netherlands is operating very close

to its capacity limits and needs to be reinforced. Besides building more hardware, such as cables and substations, matching supply with growing demand can also be achieved by implementing software to make optimised use of the existing hardware as 'virtual grid reinforcement', without getting into cable overload that leads to accelerated degradation. The challenge is to rightly allocate the electricity that will be used in time and in the geography of the grid, considering everything from feed-in from solar farms to usage patterns caused by dynamic energy contracts and, for example, football matches.

The workshop research team's task was first to select the most effective approach and subsequently develop the outlines for a solution with that approach. Scientific Software Engineer Jerry Jinfeng Guo from Alliander supervised the case. 'As case owner, I am extremely impressed by the team's motivation, performance and results. I saw swift self-organisation and efficient collaboration, which led to convincing results. At present, we are really looking forward to the outcomes of the follow-ups that we plan with part of the same team.'

'WE REALLY LOOK FORWARD TO THE OUTCOMES OF THE FOLLOW-UPS THAT WE PLAN WITH PART OF THE SAME TEAM'

Jerry Jinfeng Guo

LASTING BONDS

Co-organiser Driessens was impressed by how hard the teams worked all week long. 'We had scheduled breaks meant for relaxing and networking, but nobody showed up,' he says, laughing. 'The enthusiasm, not in the least from the academic leads, to make a real contribution was overwhelming. This enthusiasm proved to be contagious, as Contractuo has already announced its wish to participate next year with new cases.' Driessens believes that within the teams, lasting bonds have been forged, also between companies and researchers. 'Yet the end of the week is definitely not the end of things. In the wake of the event, case owners can draw up the balance sheet: what do the results mean for us and how do we follow up on them? Follow-up projects with (part of) the team can, for instance, be brought to the table – as in the case of Alliander. Or, alternatively, thinking about next year's case can be started – as in the case of Contractuo.'

Kurt Driessens

'THE ENTHUSIASM, NOT IN THE LEAST FROM THE ACADEMIC LEADS, TO MAKE A REAL CONTRIBUTION WAS OVERWHELMING'

The power of semantics for meaningful computing

By Bennie Mols Images Ivar Pel

GROUP PASSPORT

RESEARCH FIELD

Ontologies, ontology-driven conceptual modelling, systems security, data security, service design theories, model-driven engineering, Internet of Things

INSTITUTION

Faculty of Electrical Engineering, Mathematics and Computer Science (EEMCS) of the University of Twente

EMPLOYEES as of September 2025

Total 55:
3 professors, 4 associate professors,
8 assistant professors, 3 lecturers,
9 associate researchers, 28 PhD students.

WEBSITE

www.utwente.nl/en/eemcs/scs

From healthcare to cybersecurity: the Semantics, Cybersecurity and Services (SCS) group at the University of Twente applies structured knowledge to make digital systems smarter, safer, and more meaningful.

Giancarlo Guizzardi

Andrea Continella

Taru Itäpelto

'Computer Science is often preoccupied with data and with the computer as a data manipulation machine', says Giancarlo Guizzardi, leader of the research group Semantics, Cybersecurity and Services (SCS) at the University of Twente. 'But data refer to things, people, events, and relationships in the real world. If we want to build digital systems that we can understand and trust, we need to have a good way of working out the relationship between the data and what the data represent. That is called semantics. An important part of the research in the SCS group is building so-called ontologies to address current problems in data management, cybersecurity, and the interoperability of digital systems. Our group is quite unique in its approach.'

The importance of semantics is great, but too often overlooked. Suppose a hospital and a general practice record medical information about the same patient, but using different terms. Let's say the hospital uses the term 'myocardial infarction', while the general practice talks about 'heart attack'. Without additional explanation, a computer does not know that a heart attack is the same as a myocardial infarction. This problem can be solved by giving the computer an ontology, a structured description of knowledge about a particular subject: what things are, what they are called, and how they are related.

Guizzardi's group has developed several ontologies that are used in practice. 'Grounding all these ontologies is a foundational theory called the Unified Foundational Ontology, UFO in short', says Guizzardi. 'Currently, it is in the process of ISO standardisation. Over the years, UFO and a modelling language based on it called OntoUML, have been successfully employed by many organisations worldwide. The National Health Care Institute, for example, has used it for safe data exchange among a multitude of systems. Moreover, organisations such as NASA have repeatedly demonstrated interest in these results.'

What binds the group's work on semantics, cybersecurity and services together is what Guizzardi calls 'meaningful computing'. Guizzardi: 'Meaning in the sense of semantics but also in the sense of purpose: building systems that are aligned with human values and norms. Recently, we have been developing ontologies that help to operationalise ethical norms proposed by the EU by translating these into concrete rules that engineers can use to build ethical systems.'

Triaging security alerts

Within the SCS group, associate professor Andrea Continella leads the cybersecurity team. Continella: 'We focus on designing new techniques to test, prevent, or mitigate cyberattacks. Among the systems we look at are cloud systems and IoT systems. Recently, we built our own IoT Cyber lab: a room that replicates a studio apartment equipped with IoT devices like a smart fridge, a smart alarm system, and even a smart bed with sensors below the mattress. In the lab, we test smart devices in terms of security.'

One of the interesting results of Continella's work is in the field of alert triaging. This is the problem that nowadays many security systems give too many security alerts to act on all of them. 'We have used a combination of AI and semantic technologies to build a model that can group the most important security alerts together, so that security operators don't have to go through all of them but know which ones have priority. Using data sets from real-world companies, we measured that our solution reduced the workload of the operators by ninety per cent.'

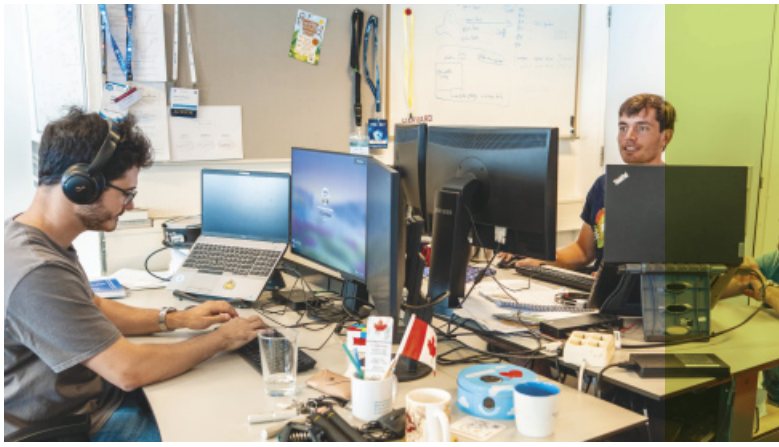
Over the past five years, the SCS group has grown quite a lot, Continella says. 'But at the same time, the group has grown into a research family, a dynamic and friendly environment where people help each other and have fun together. Beyond research, we play together in international hacking competitions under the Twente Hacking Squad team, and in our IoT lab we have installed a football table that we made smart with sensors tracking goals and replaying the match highlights.'

Protecting infrastructure

PhD student Taru Itäpelto began her career as a professional musician in several symphony orchestras in Finland. She later transitioned to entrepreneurship, working as the CEO and CFO of a foster care company before discovering her passion for cybersecurity. Now she is researching how to leverage digital twins to improve the cybersecurity of critical infrastructures. 'Such systems have life cycles of thirty to forty years', she says. 'In the meantime, various components are updated, and external threats evolve, leading to a changing cybersecurity landscape. So, the key question is: How to ensure the cybersecurity of a critical infrastructure throughout its lifetime?'

An example that Itäpelto has been working on is a small surveillance system that can be incorporated in any critical infrastructure. 'I have looked at how we can use ontologies to build a digital twin model that is robust against changes. Even if a camera is replaced, the system's security should remain intact.'

Itäpelto says that the social aspects of the SCS group are similar to what she was used to in Finland: 'There's a flat hierarchy, and it's easy to communicate with everyone. This, combined with the strong social connections, means I feel valued and included in this group.'



Dimka Karastoyanova is a full Professor of Information Systems and head of the Information Systems Group at the University of Groningen, where she also acts as the vice-chair of the Bernoulli Institute Board. Karastoyanova holds a PhD in Computer Science, an MSc in Computational Engineering, and an MSc and BSc in Industrial Engineering. Since May 2025, she has been a member of the board of IPN.

VIBRANT AND AMBITIOUS COMMUNITY

Whether it concerns her research into adaptive systems for process automation or her managerial tasks, Professor of Information Systems Dimka Karastoyanova aims to make processes run smoother. In May 2025, she joined the board of IPN. 'I want to contribute towards improving the standing of the Dutch informatics research community and the funding availability from industry and government.'

By Sonja Knols
Image Henk Veenstra

What is your research about?
'I am working on adaptive systems for process automation and performance improvement. Or, in other words, on software that changes while it is being used to steer automated processes.'

What type of applications do you typically work on?
'Anything ranging from manufacturing, logistics, and supply chain management, to data science and healthcare. That diversity is also what makes this field interesting. Even in a similar field, the context can still be vastly different. Producing cars is not the same as producing computers, and treating patients is different for every other disease. Since each domain has its own way of measuring requirements like flexibility, cost, and sustainability, it is important to map characteristic features of the process at hand and work with different models of performance metrics and indicators.'

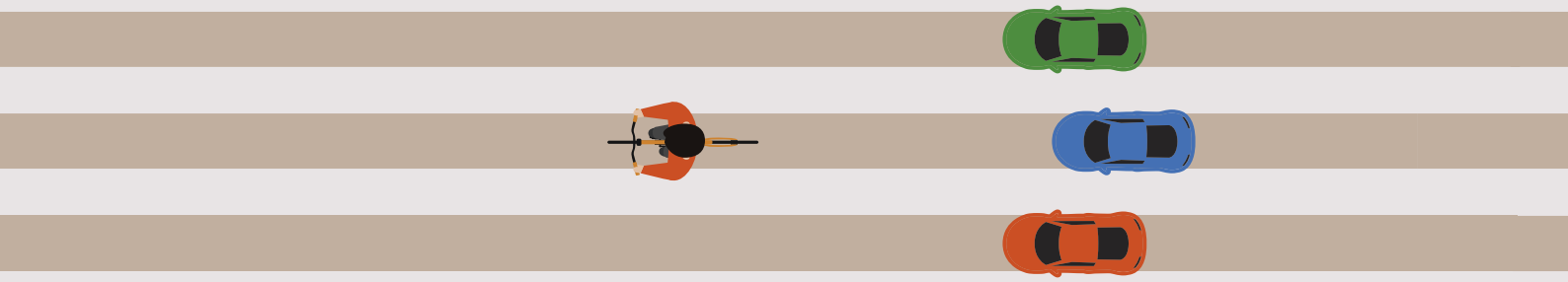
What is the biggest challenge in your field?
'My current research is mostly aimed at environmental impact and sustainability of processes and process-aware information systems. But at the moment, we lack sufficient data to accurately assess the environmental impact of process automation. Companies have to report about their total CO_2 emissions, for example, but they do not have detailed data about the software contribution to the environmental impact.'

From early on in your career, you have taken up management positions. Why?
'Because it is a great learning experience, and because I like to organise activities that help others. For example, shortly after I came to Groningen, I became head of the Department of Computer Science, which helped me understand the dynamics of the department and the Bernoulli Institute that it is part of. For me, coming from abroad, engaging in the department's management was also a good way to learn about the Dutch culture and how people interact with each other here.'

Last May, you joined the board of IPN. What is your ambition there?
'I would like to contribute towards improving the standing of the informatics research community, demonstrate its significant impact towards solving real-life societal problems, and advocate for increased funding availability from industry and government. I also support putting more effort into maintaining open and transparent communication towards the IPN members. I am convinced that placing the focus on these perspectives will ensure that every ICT researcher feels proud of being a member of a vibrant, ambitious and fair community.'

SEEING MORE WITH LESS

By Bennie Mols Image iStock



In a new NWO Vici project, Jan van Gemert aims to develop computer vision systems that achieve state-of-the-art accuracy with a hundred times less data.

In a short essay called 'The Bitter Lesson', Turing Award winner Richard Sutton stated that success in AI does not come from explicitly incorporating human knowledge, but from building systems that can learn and discover on their own, fuelled by ever-increasing computing power and the abundance of data. Examples abound, Sutton writes: in games like computer chess and go, but also in machine translation and computer vision.

Jan van Gemert, head of the computer vision lab at Delft University of Technology, refers to Sutton's essay to characterise the current trend in AI: 'It is all about more data and more compute. At companies like Meta or Google, a single person can use more GPUs than our entire department has. I am no longer even trying to compete with that. In my research, I'm deliberately going against that trend.'

Using prior knowledge

Van Gemert received an NWO Vici grant for his 'Project dAIta: Data Efficient AI Foundation Models'. 'My hypothesis is that you need much less training data in computer vision when you use prior knowledge about physical properties of the world', Van Gemert explains. 'And using less data not only means less computation but also fewer biased outcomes, less privacy and copyright issues, and a decreased dependency on Big Tech companies.'

Van Gemert started the Vici project in July 2025. Three PhD students will each work on a different subtheme, followed by the hiring of a postdoc to integrate their research. Van Gemert: 'Each PhD student will explore a different aspect of prior world knowledge: one will focus on depth, another on lighting conditions, and the third on the compositional structure of objects.' Neural networks recognise objects by colour differences, such as a bicycle in front of a red, green, or blue car. They memorise those colour differences by heart, which demands many data samples per colour. 'But if we use estimated depth differences instead, one example is enough', states Van Gemert, explaining the first idea of using prior knowledge. 'This will also work for rare colours like pink cars that are not in the data.'

In the second idea, different lighting conditions are explored. For a camera, a bicycle looks different under cloudy or sunny skies, but again, it's still the same bicycle. With the third idea, Van Gemert will allow the system to learn that a blue and a red variant of the same bicycle differ only in colour, but not in shape. For current systems, those two bikes are totally different. When they have learned to recognise a blue bike, they have to start again from scratch to recognise a red bike.

Tracking improvement

Van Gemert: 'I hope that the Vici project will allow computer vision systems with a hundred times less data to achieve the same accuracy as state-of-the-art systems.' He wants to do that with a novel approach. Many AI systems are currently built by trial and error. Then at the end of the run people say, "look, it works". In my opinion, too little research is done on where exactly the improvement comes from. I'm more into understanding, rather than trial and error.' He points to the whiteboard behind him, on which words like *Dlaczego? Pse? Neden? De ce?* are written. 'The question I ask my students most often is "why?", so I asked each of them to write the why-question in their own language on the whiteboard.'

More information
jvgemert.github.io

MAKING VITAL INFRASTRUCTURE FUTURE-PROOF

Many large infrastructure systems, such as bridges, tunnels, sluices and floodgates, were built in an era when digital modelling and mathematical analysis either did not exist or were considered purely theoretical concepts. Rijkswaterstaat is now exploring how the benefits of formal, model-based approaches can be applied to develop working control system models of the assets in its portfolio. The goal is to ensure their sustainable maintenance for the duration of their expected lifespan, which is often 50 years or more.

By Leendert van der Ent
Images WAT ontwerpers, iStock

Over the past years, Jan Friso Groote, full Professor of Formal System Analysis at Eindhoven University of Technology, was responsible for modelling the control software of the Maeslantkering. This is the largest and most complex system of them all. On behalf of Rijkswaterstaat, Programme Manager Yigal Levin acted as his counterpart. Both agree that the fusion of in-depth domain knowledge with formal modelling expertise is essential for the success of such projects.

Groote wishes to make one thing crystal clear up-front: 'We are not talking about a simplified version of a partial model of an object here. This is about a model describing the complete control software with all of its real-world functions.' Two challenges stand out during the execution of such a project, he says: 'It is very hard to find out what software in actual systems is doing, or is supposed to do precisely. But if you make a formal model, you have to know. I have seen many people trying this for systems far less complex than the Maeslantkering, who gave up. But not in this case. With the excellent support of Rijkswaterstaat, we managed to produce the precise model.'

'IT IS VERY HARD TO FIND OUT WHAT SOFTWARE IN ACTUAL SYSTEMS IS DOING, OR IS SUPPOSED TO DO PRECISELY. BUT IF YOU MAKE A FORMAL MODEL, YOU HAVE TO KNOW'

This typically regards questions about detail, such as: 'You are supposed to push this lever once. But what happens when you push it twice or three times?' This requires sharpness from the modeller and answers that even the experts have not always thought about, because you are not supposed to do it. Groote: 'But since it can happen, you have to think about it. As a modeller, you should not seek the solution by yourself, but follow the thinking of the object expert in a dialogue. That is the first challenge.'

SIZE OF THE MODELS

The second challenge is related to the limits of the "human condition". Groote: 'We need to describe a system integrally and correctly – but we know that we as humans make errors while doing this. A plus sign is easily switched for a minus sign when it is close to cup-a-soup time. We therefore have to verify the entire model in all its behavioural characteristics in all possible variants.'

But this verification is hard because the models are big. There are only 10^{80} atoms in the universe. 'However, the number of different situations a software controller, such as for a railway network or a tunnel, can be in can easily exceed 10^{1000}, says Groote. It is hard to wrap your head around that. 'If the model contains too many of these situations, which we call states, then it becomes impossible to verify all states. Therefore, we need to make a model restricting the number of states, without compromising the principle of simplifying the model compared to reality. For instance, there should be no shenanigans when modelling malfunctions of sensors and actuators. We managed to do this with the Maeslantkering. When we mathematically analysed the behaviour of the model, it outwitted the experts. This built trust in the model.'

SUSTAINABLY MAINTAINABLE

Yigal Levin, Programme Manager at Rijkswaterstaat, explains the rationale behind the effort: 'We need to be able to trust that the assets we manage behave exactly as they were designed to without surprises. Most of the tunnels, bridges, and sluices under our responsibility were built between the 1950s and 1980s. Their physical structures were designed in a highly structured way, based on clear calculations of structural strength; something you can still verify in the technical drawings. The digital control systems of these complex assets should be designed just as systematically. But with legacy ICT systems, it's very difficult to demonstrate this in retrospect. This calls for ongoing professionalisation.'

'To catch up, we're now building that proof using formal models developed by highly experienced institutions such as Eindhoven

University of Technology and the University of Twente. This approach helps us prepare for future developments by making our systems future-proof and sustainably maintainable.' A crucial aspect for successful modelling is the collaboration between the genuine domain experts of the asset management organisation and the ICT specialists of the contractor. Groote: 'As accuracy is vital, interpretation must be ruled out as much as possible. Ultimately, you have the back-end verification tool mCRL2 to prove the validity, but effective communication with the right level of Rijkswaterstaat domain experts helped to prevent misunderstandings and thus to work efficiently. I have great appreciation for the fact that Rijkswaterstaat understood how important it is to spare their scarce domain experts for this project. Not every organisation understands how vital that is.' Levin adds: 'Our collaboration has been very productive indeed, also thanks to the knowledge level and methods applied by the researchers in the project. The model proved to be nearly 100 percent correct right away. Reliable models like these are vital for our future as an asset manager.'

INTEGRAL MODEL

The same approach is also applicable for other assets within Rijkswaterstaat, such as sluices, bridges and tunnels, but also for systems outside the organisation, Levin emphasises, such as railway networks or nuclear power plants. 'Having verifiable models creates peace of mind.' Groote is also glad that a complete approach with modelling principles and modelling language is in place, creating models with infinitely more precise language than natural language could ever produce. 'I must admit that the integral model we have now is something of a surprise even to me.'

'WE NEED TO BE ABLE TO TRUST THAT THE ASSETS WE MANAGE BEHAVE EXACTLY AS THEY WERE DESIGNED TO WITHOUT SURPRISES'

'Many projects of this type get stuck halfway', he says. 'The ambitions are then tuned down, for instance, to the creation of a partial model. No such thing is happening here: we have modelled the entire Maeslantkering, with opening and closure processes true to nature. That is no trivial feat, given the complex interaction of the Maeslantkering itself with the weather and hydrology dynamics at large. All things considered, this is an achievement we can rightly be proud of.'

EMPHASIS ON THE HUMAN SIDE

By Sonja Knols

Stefan Schlobach

Head of the Department of Computer Science at VU University

'In recent decades, computer science education has grown tremendously. We now have four times as many students as twenty years ago. Unfortunately, we were not able to hire enough new talent to meet the growing need for education. As a result, our staff hardly had enough time to be competitive, let alone to develop new out-of-the-box ideas.

The sector plan funds represented a structural investment in Dutch computer science expertise, bringing a more stable perspective that is necessary to foster creativity.

In the two successive sector plan rounds, our department was awarded a total of 14 new positions. We not only used these to fill the gaps and reinforce the relationship between research and education, but also to strengthen the fields we had already established a position in and enrich them with a human-oriented angle.

We deliberately invested in the socio-technical side of computing, resulting in new collaborations and interesting crossovers. For example, we created a position on privacy and security for AI systems, thus linking our foundational security group to our AI-oriented work.

Since many of our new hires are internationals and female, the diversity among the staff has definitely increased, which also contributes to the creativity. In addition, the composition of our staff now better matches that of our international student population.

The sector plans have brought our department a more stable perspective, also for the longer term. For example, we invested in the human side of artificial intelligence in connection with the NWO Gravitation programme Hybrid Intelligence. That is a temporary, ten-year programme. By linking new permanent positions to it through the sector plan funds, we have ensured that when the programme ends, we can continue building further on its results. Without the sector plan funds, there would have been no guarantee that the Hybrid Intelligence work could be continued. What's more, the people-oriented side of security research that is now well established at VU University would not have been there at all. And since we were able to solve certain bottlenecks with the sector plan funds, we could use our existing budget to invest in other areas as well. For example, we managed to strengthen our commitment to massive computer systems, and we made room for topics like digital sustainable societies and bioinformatics. All in all, we have achieved critical mass in a variety of subject areas, which will keep bearing fruit for decades to come.'

The two successive sector plans have resulted in a significant number of new hires at various Dutch universities. Stefan Schlobach, Head of the Department of Computer Science at VU University, explains how the funds have provided a basis for stable growth. Emitzá Guzmán, assistant professor at his department, explains how she values the possibility to continuously reinvent herself and stay relevant.

Emitzá Guzmán

Assistant Professor in Socio-technical Systems at VU University since July 2019

'After obtaining my PhD at the Technical University of Munich, I went to Zurich for a postdoc. Since I do applied research, I wanted to gain a better understanding of our field in practice. So, I found a job in industry. Even though I really liked my work as a data scientist, I soon realised that my place is in research. Being an academic enables me to continuously reinvent myself and to remain relevant throughout many hypes.

My PhD research was about socio-technical problems in software development. What attracted me to the position here in Amsterdam was that I did not have to sneak in the social part; from the start, the job was open to taking the human angle to computer science.

My work roughly focuses on two areas. The first is about understanding the organisation and dynamics of software teams, and how those affect the software they deliver. How, for example, do micro-inequities, like constantly getting eye rolls or being interrupted, impact people and their performance and, in turn, the software they design and develop?

My second main area is on ethical issues in software from an end-user perspective. We answer questions like: What are users worried about when working with software like social media, productivity apps, or games? We conduct interviews, design and distribute surveys, and look at texts online, for example, in the App store or in Reddit reviews, to take stock of what people have to say about privacy, content moderation and discrimination in software platforms, and their environmental impact. With automated approaches that use AI and general statistical methods, we analyse, classify and prioritise how these concerns change over time.

We do not take just a Western point of view, but also include concerns of marginalised or minoritised groups and countries from the Global South and the Middle East. It is very interesting to see how local cultures influence the ethical concerns users have. For example, privacy is of a much higher concern in Germany than in Pakistan, where people are used to sharing one phone among family members.

I would like to continue my research into ethics and team dynamics, and analyse how both are connected. In the future, I would like to extend this work to include policymakers and make suggestions for change. When it comes to ethical concerns about software, we are only scratching the surface. There is so much more work to be done on the topic.'

RECONNECTING SCIENCE AND SOCIETY

By Leendert van der Ent Image Ivar Pel

Given the huge technological changes we are going through, science must reflect on its working methods, says Vanessa Evers. She envisions a scientific world that remains curiosity-driven, yet finds new ways to connect with society.

'The combination of Large Language Models, Crypto, Quantum, AI and robotics will bring about rapid changes. Intelligence inside robotic bodies will have a huge impact on many aspects of society, but exactly how is hard to predict. Scientists can only advise governments on the legal and regulatory implications. In the USA, in particular, there is already a surge in litigation over the decisions taken by surgical robots. That is interesting because, unlike a human surgeon's decisions, a robot's decisions are only based on traceable data.

Another interesting aspect is how prosperity in the Netherlands shows the triumph of the blue sky research model. And yet, despite all the evidence of return on investment from research funding, governments are cutting budgets for research with unknown outcomes. But regardless of the politics, one thing is certain: once budget cuts destroy the Dutch infrastructure for science, we won't be able to simply turn back the clock. Yet despite the consequences, we are moving in this direction.'

ENGAGED SCIENCE

'Given this situation, we should not only work together with social sciences, humanities and the arts, but also involve citizens even more in our research, which means going beyond citizen science projects. That means starting with the question: what do we as a society think is important, and how can science contribute? Many people have serious concerns that could also be addressed with some facilitation from scholars and scientists. Then, instead of people just being scientific subjects, they would more often get the outcomes they need from researchers. In some areas, a new model of community science could emerge where transdisciplinary, added-value teams of scholars, people from government or business, and scientists could take on challenges together with societal groups. Research, including blue skies research, could achieve broader engagement and sustain public legitimacy.'

In September 2025, Vanessa Evers started as Director of Centrum Wiskunde & Informatica (CWI) in Amsterdam. Before this, she was a full Professor of Computer Science at the Human Media Interaction group, University of Twente, and Director of the Institute of Science and Technology for Humanity at NTU in Singapore. She obtained her MSc in Information Systems at the University of Amsterdam and a PhD at the Open University, UK.